brought into rotary motion, which drives the surface-air away from a centre. The vapor atmosphere is thereby caused to approach the earth's surface, and by thus descending is brought under greater pressure, so as to give off rain at the centre of the cyclone, as explained above.

Having, by a simple way of reasoning, arrived at the conclusion that an atmosphere of pure aqueous vapor must exist outside the atmosphere proper, we should not feel justified in stopping without carrying our idea out in at least some of its consequences, although the following remarks do not concern our immediate subject, the cause of rain. Supposing there was an outer limit to this aqueous atmosphere, the difficulty which would present itself is, that we should find aqueous vapor alongside of the vacuum of space. It is well known that when moisture is brought into an artificially produced vacuum, the latter gets instantaneously filled with aqueous vapor. How is this experiment to agree with the popular notion that vapor, as well as the other constituents of the atmosphere, is kept within limits round the earth by means of gravitation? If the vapors of the supposed outer border of the atmosphere were prevented from entering space owing to gravitation, how much more would the vapors at the bottom of an artificial vacuum be prevented from filling this space, as the force of gravity is much the greater at the earth's surface than at a supposed outer border of the atmosphere?

SCIENCE

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EIGHTH YEAR.
VOL. XV. No. 370.

NEW YORK, MARCH 7, 1890.

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AN ELECTRIC SNOW-PLOUGH.

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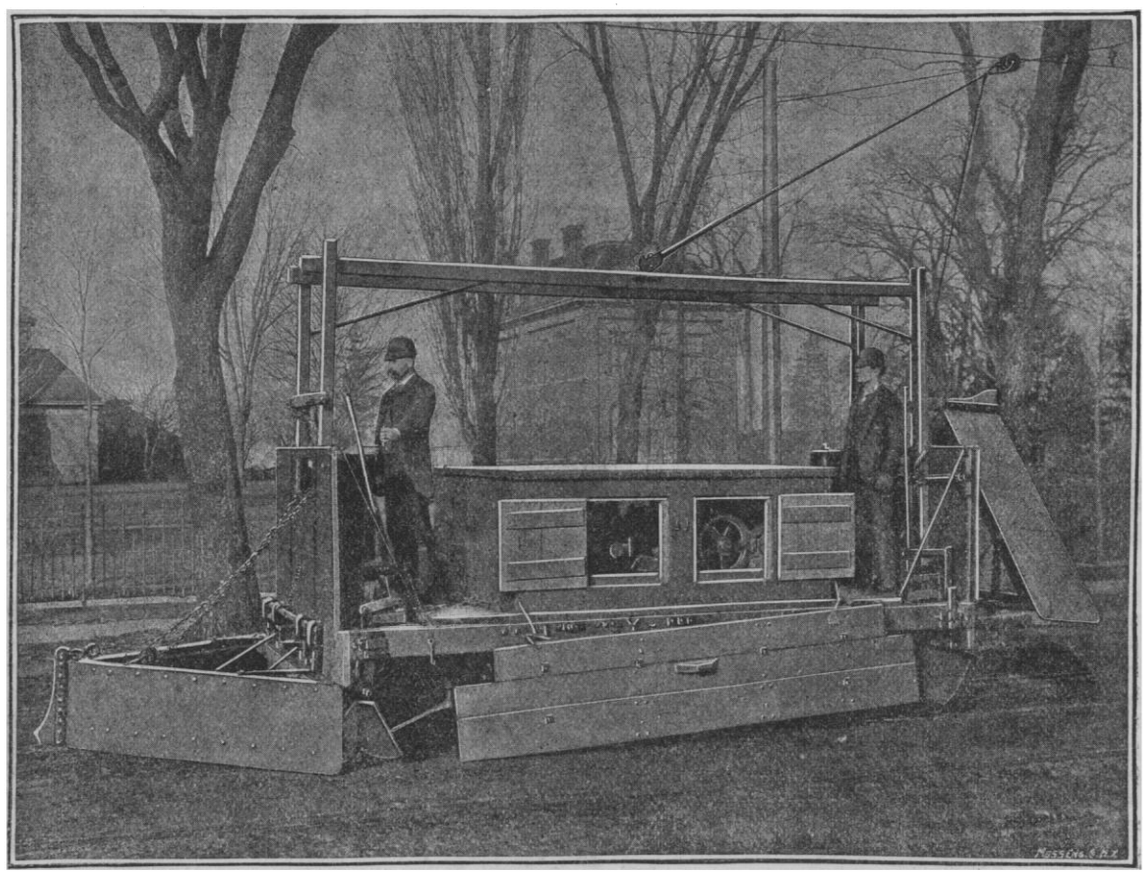
The greater number of these electric railways are in the northern part of the country, where, during the winter months, snow often becomes a serious obstacle to travel. To rapidly and economically remove this obstacle from the tracks as soon as possible after each snow-storm, electric snow-ploughs have been constructed, one of which, manufactured by the Sprague Electric Railway and Motor Company, is shown in the accompanying illustration. It is fitted with two fifteen horse-power improved motors, and is so arranged that it can be run either forward or backward, similar to an electric car. The reduction in gearing between the motors and the car-axles is greater than in the ordinary electric car, so that a large amount of power is available from the motors in case of necessity. It is estimated that this plough will clear the track more speedily and effectually than an ordinary snow-plough drawn by twelve horses.

The view shown is from a photograph of a plough which has been in operation for some time on a street-railway in Troy, N.Y. Although the season has not as yet offered much chance to show the capabilities of the plough, it has effectually taken care of several light falls of snow which have obstructed the tracks this winter.



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THE Hale pavement, shown in section in the accompanying illustration, consists essentially of a shell of hard-burned bricks laid upon a board floor having a bed of sand below and above it. It is constructed in the following manner. The grade having been properly reduced and dressed to the required

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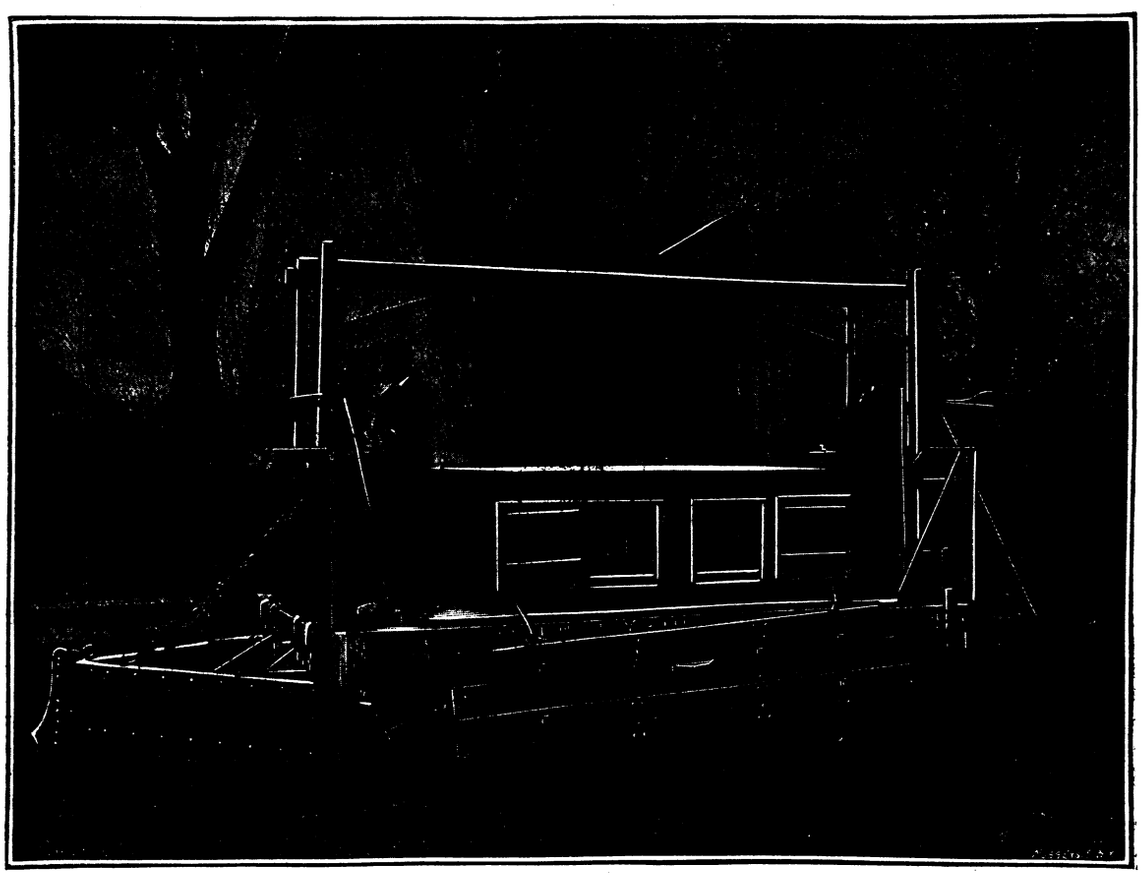

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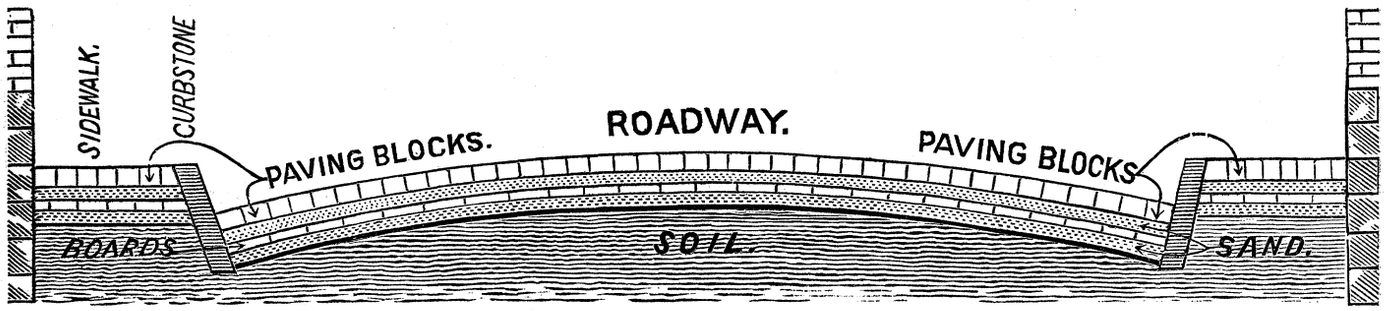
shape, the ground is covered with a layer of loose sand a few inches in thickness, to form a more perfect bed for the boards to rest upon, and to keep the boards from contact with the earth beneath, so as to form a sub-drainage against the effects of freezing weather. The sand is struck off to a perfect surface by a templet made to suit the desired curve, and guided by slats set to grade stakes.

The boards to be used need not be more than one inch in thickness, and ought not to be less than ten inches in width. The best timber for the purpose is that least subject to rot under the circumstances. Good white oak has been used successfully. The boards should be dipped in hot coal-tar or other preserving material. They are then carefully laid upon the sand-bed — lengthwise with the street would be the most convenient way — from curb to curb, with a regular curve all the way. No gutters are necessary, except such as are formed by the crown of the pavement. The broad surfaces of the boards bridge over all minor irregularities of the grading, and widely distribute all weights or pressure; and the floor forms a complete and perfect foundation for the hard material to follow. It is best to cover the boards with a layer of loose sand an inch or two in thickness, to form a more perfect bed for the bricks, which can be struck off with the templet, as before described.

The hard-burned bricks are next laid down. If they are of the ordinary shape of building-bricks in common use, they should be placed on edge, and laid "herring-bone" style, by



THE HALE PAVING SYSTEM.

which means all joints in the board floor are straddled. The seams are then filled with sand, and the bricks settled in their beds with a flatter, well rammed, or rolled with a heavy roller.

In cities having very heavy traffic to follow immediately the laying of the pavement, it is sometimes preferred, after the interstices between the bricks are half filled with fine sand, to complete the filling with hot pitch made by boiling gas-tar until the more volatile portions are driven off. This, when it cools, makes the pavement at once impervious to water, cements the bricks together, and helps to hold them firmly in place. This is generally advisable wherever clean fine sand cannot be obtained to fill the interstices.

A perceptible elasticity tends to favor the bricks when subjected to a crushing weight. The bricks being in place, their flat surfaces agreeing with each other and with the flat surface of the boards beneath, the bearings are perfect and equal: they can be broken only with difficulty, and cannot get out of place; and if at any time it is desired to lay pipes or sewers beneath the pavement, the materials, being all disconnected, can be rapidly taken up and laid aside, and as rapidly replaced at small expense, no new materials being required, and no patching to be done, every thing fitting in its place.

The durability of this pavement has been tested by several years of hard service in the streets of Charleston, W. Va., and in other places. The cost of this pavement in any given locality depends upon the cost of sand, oak or other durable boards, hard-burned brick, gas-tar, and labor at such locality; but it is claimed that it can be laid in any city or town in the United States, having length of streets sufficient to warrant the undertaking, for very much less than asphalt or Belgian granite blocks, and in most places for less than well-laid wooden blocks, or even good macadam roadways. It is controlled by the Hale Pavement Company of Staunton, Va.

MAJOR POWELL'S ADDRESS TO THE MINING ENGINEERS.[1]

MR. PRESIDENT, AND MEMBERS OF THE INSTITUTE OF MINING ENGINEERS, — It is with great pleasure that I greet you, and welcome you to Washington. The people of the United States obtain vast values from the rocks. The sum of the annual products of the mines of the United States is now more than six hundred millions of dollars. Over this production you preside. It is by your genius and skill that these industries are prosecuted. These affairs, which are confided to your guidance are not only great in themselves, but they constitute an integral part of all of the industries of the land, as they are all profoundly interdependent. The industries of manufacture, transportation, agriculture, and exchange have their interests, their prosperity, and their value to the people at large, all interwoven with the industry of mining, for the success and prosperity of which you are responsible.

Deep in the mountains lie the values which you seek; buried under the hills are the substances which you bring to light; concealed beneath the valleys are the materials which you resurrect. By your insight they are discovered. The prosperity of the land depends upon your knowledge of the structure of the earth and the secrets which lie buried in the depths of the rocks. By your knowledge and mastery over the powers of nature, all these substances are wrested from the adamantine grasp of mountain, hill, and valley, and placed in the possession of mankind. By your knowledge of the constitution of the rocks, and the various processes by which they may be transformed, these substances, so useful to mankind in the industries of civilization, are extracted, and transmuted into forms ready for the use of the people. But for your agency, the factory-wheels of the land would stop, the life of transportation would expire, the valleys of agriculture would be reforested, and the marts of exchange, now trodden by busy feet, would be clothed by a mantle of desolation.

That labor may be successful, that the ever-increasing wants of ever-increasing men may be supplied, labor must have guidance. In the centuries that have passed, tyrants have directed laborers as slaves, or held them under control as abject servants of want; but under modern culture the laborer is emancipated from slavery supported by chains and whip, and the slavery supported by want and dependence. Muscles of brawn are no longer shackled; but by your transcendent genius the powers that gleam from the sun upon the world, the powers that flow in great rivers, the powers that are concealed in banks of coal, filling the hills and mountains, the powers that lurk in the chemical re-actions of the rocks that constitute the crust of the earth, — all these powers are enslaved, all these powers are shackled, all these powers are made the servants of mankind. The crack of the lash is superseded by the glint of thought. The modern rulers are the men who control the powers of nature.

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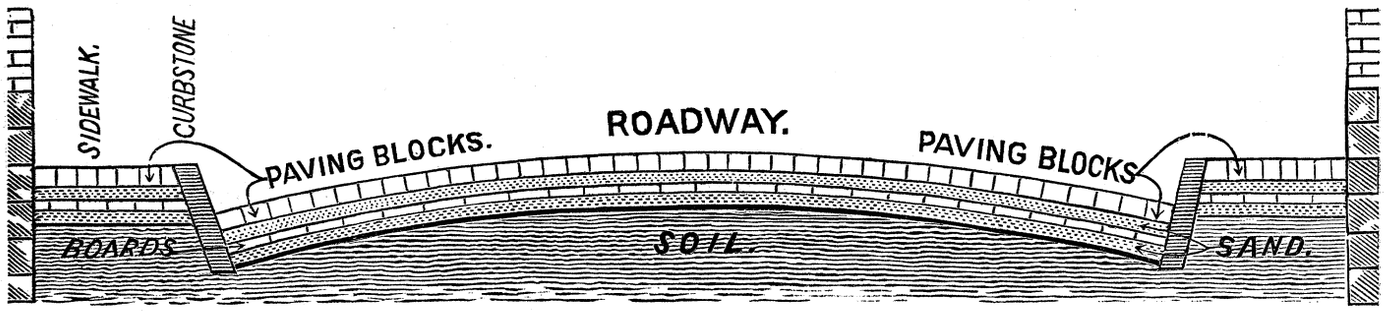

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erations and administrations so profoundly affect the welfare of mankind; and yet this body is held together as an organization of free men, each independent in his own sphere, governed only by a body of science, which is the common property of all, and the aggregated progress of research, invention, and exploitation. The efficient constitution and by-laws of this society are the formulated principles of science. For the organization of the labors of the past, the whip for the back has been the proper emblem of sovereignty. For the organization of the labor over which you preside, the hammer for the rock is the emblem of rule. You want in your deliberations no eagle on your mace, no unicorn and lion; but the balance and crucible properly symbolize to the world the power of your knowledge to control the industries of mankind.

Gentlemen, the industries which you control have their location in the foundations of the world. The valleys through which the living rivers roll, the prairies that spread their blossoms of beauty to the sun, the hills that billow with ripples of perpetual joy, the mountains where kissing clouds are transformed into cascades decked with rainbows, — all forms of land have their foundations laid in interlocked, crystalline gems, firmly set in a cement so delicately formed that the highest powers of the microscope fail to reveal its structure. The vast diastrophic powers of nature are forever engaged in mountain-building, against which the clouds hurl their storms to carve the hills and form the valleys; and, as the mountains appear above the level of the sea, the clouds bear them away on river-floods to build the fringing islands that are bathed by the tides. As these processes go on from geologic age to geologic age, the gold and the silver, the copper and the lead, the iron and the coal, and all the various substances with which you deal, are gathered in lodes, and segregated in bodies, and spread in strata, and are thus by nature separated from the great crystalline foundations of the world, and accumulated in masses. Then bounteous Nature repents of her generosity. Seeing what a store of wealth she thus brings together, she conceals it from the eye of the vulgar, and deems these treasures too precious to be intrusted to the ignorant. So she hides them away in fissures and in caves, she buries them under volcanic floods, she covers them with strata spread out by the waves of the sea; and she spreads over all a mantle of *dèbris* —of bowlders and gravels, and sands and soils; and over all she paints the bloom of the meadow, the variegated pattern of the copse, and the green of the forest; and then she smilingly exclaims, "My treasures are for those who can discover them. They who are worthy, by their intelligence may find; they who are unworthy, by their ignorance must remain destitute."

The people of the United States have chosen you — not by blind natural selection, but by intelligent choice—as their representatives; not to make laws, but to discover laws, — the laws of nature, by which all these concealed treasures may be brought to light, and fall into the possession of mankind. How well you administer the trust the six hundred millions of annual mining product in the United States attests.

I thank you, gentlemen, for this evidence of your labor and genius, and I congratulate your constituents for the choice they have made.

There is an organization with which I am connected, — the Geological Survey, — established by the general government, and endowed by the munificence of the people, that is working in cooperation with many other organizations established by the several States, the purpose of which is to aid you in your work. This organization is endeavoring to map the entire area of the United States for your purposes. It is endeavoring to trace the various geologic formations, and to discover their relations of sequence and interdependence. It is investigating the more recondite laws which control the distribution of values in the crust of the earth. All these things it is doing to aid you in developing the mining industries of America. Let me assure you, as a representative from this body, that we are informed with the same purposes as yourselves, and that we also believe that research is a boon to mankind, in part through the increase and diffusion of knowledge, but in larger part through the increase and diffusion of industrial blessings.

The history of the mining engineering of America is replete with the triumphs of science. In the Far West, where the soft breezes of the Pacific make music on giant Sequoian harps, there they harness rivers to monitors, and plough the mountains for gold; and the mining engineers, turning from these mighty tasks, engage in the deft and delicate work of extracting the grains of gold from the mountains of sand. Elsewhere they penetrate through shafts into subterranean depths, and employ, in gold and silver mining, machinery for power and efficiency elsewhere unparalleled. From the depths of the mountain they pump rivers thousands of feet to the surface, and they shoot cars of ore from the hell of darkness below, to the heaven of light above, as if they were playing with toy-guns, such Titan boys are they. Farther to the east, all over the land, the mining engineers are opening the great coal-fields, and gathering the sunshine which nature has been storing for unnumbered centuries in the depths of the earth. In the lost years the vegetation of America raised its verdant arms to heaven, and, grasping the glad sunlight, fell prostrate on the ground, and, still clinging to its boon of light and heat and power, was buried in great coal-formations beneath the accumulating sands of seas. This fossil power and heat and light are brought once more to the open day, and employed as powers for the machinery of America in warming the homes where wives and children dwell, and in illuminating the towns and cities of the land. These mining engineers have discovered that ofttimes the strata of the earth are domed by geologic upheavals, and that they thus constitute great natural receivers for the gases distilled in the depths below. Into these receivers they penetrate with their tubes; and, behold! light, heat, and power are given to the world. Time would fail to tell of all the triumphs of the mining engineers of America.

Gentlemen, I welcome you to Washington, and hope that your deliberations may be wise, and that your joy in our midst may be complete.

ELECTRIC WELDING.

IN accordance with instructions from the City of London Contract Corporation, Limited, Alexander B. W. Kennedy, F.R.S., vice-president of the English Institute of Mechanical Engineers, recently visited the United States in order to see what progress has been made in the direction of the practical carrying-out of the Thomson electric welding process. His report is dated Feb. 1. He visited the offices at Boston, and also spent about a week at their works at Lynn, Mass. He also visited five different works in the Eastern States (at Hartford, Ansonia, Brooklyn, and Trenton) where Thomson electric welders have been in use for some time (in some cases over a year) commercially.

The welding of iron and steel wire was one of the first matters successfully carried out by the company. He saw at the works of Messrs. Roebling, Sons, & Co., at Trenton, a welder which had been at work there for about thirteen months, for a great part of the time twenty hours per day, and the counter of which showed that 193,890 welds had been made with it. He also examined another wire welding machine at the Trenton Iron Works (Messrs. Cooper, Hewitt, & Co.), which had done about nine months' work, and had made 22,095 welds, and at the same works a portable machine, recently installed, which had made 9,022 welds. This last machine was so arranged that it could be carried about easily by two men, and connected with the mains at any part of the immense shop in which it was placed, so as to be used for mending or other welding, wherever required, without the necessity of bringing a heavy coil of wire to it. The managing partners of both the works spoke in the highest terms of the efficiency of the machines, and as to the great saving caused by their perfect utilization of short lengths and broken wires. The welding of brass and copper wire, especially the latter, naturally presented much greater difficulties than that of iron wire, but those seem now to have been overcome. Mr. Kennedy saw at the works of Messrs. Wallace & Sons, in Ansonia, a welder for this purpose, which was one of the first machines put down, and had made 30,415 welds (by register) during the last thirteen months in copper and brass wire; the latter, in

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The history of the mining engineering of America is replete with the triumphs of science. In the Far West, where the soft breezes of the Pacific make music on giant Sequoian harps, there they harness rivers to monitors, and plough the mountains for gold; and the mining engineers, turning from these mighty tasks, engage in the deft and delicate work of extracting the grains of gold from the mountains of sand. Elsewhere they penetrate through shafts into subterranean depths, and employ, in gold and silver mining, machinery for power and efficiency elsewhere unparalleled. From the depths of the mountain they pump rivers thousands of feet to the surface, and they shoot cars of ore from the hell of darkness below, to the heaven of light above, as if they were playing with toy-guns, such Titan boys are they. Farther to the east, all over the land, the mining engineers are opening the great coal-fields, and gathering the sunshine which nature has been storing for unnumbered centuries in the depths of the earth. In the lost years the vegetation of America raised its verdant arms to heaven, and, grasping the glad sunlight, fell prostrate on the ground, and, still clinging to its boon of light and heat and power, was buried in great coal-formations beneath the accumulating sands of seas. This fossil power and heat and light are brought once more to the open day, and employed as powers for the machinery of America in warming the homes where wives and children dwell, and in illuminating the towns and cities of the land. These mining engineers have discovered that ofttimes the strata of the earth are domed by geologic upheavals, and that they thus constitute great natural receivers for the gases distilled in the depths below. Into these receivers they penetrate with their tubes; and, behold! light, heat, and power are given to the world. Time would fail to tell of all the triumphs of the mining engineers of America.

Gentlemen, I welcome you to Washington, and hope that your deliberations may be wise, and that your joy in our midst may be complete.

ELECTRIC WELDING.

IN accordance with instructions from the City of London Contract Corporation, Limited, Alexander B. W. Kennedy, F.R.S., vice-president of the English Institute of Mechanical Engineers, recently visited the United States in order to see what progress has been made in the direction of the practical carrying-out of the Thomson electric welding process. His report is dated Feb. 1. He visited the offices at Boston, and also spent about a week at their works at Lynn, Mass. He also visited five different works in the Eastern States (at Hartford, Ansonia, Brooklyn, and Trenton) where Thomson electric welders have been in use for some time (in some cases over a year) commercially.

The welding of iron and steel wire was one of the first matters successfully carried out by the company. He saw at the works of Messrs. Roebling, Sons, & Co., at Trenton, a welder which had been at work there for about thirteen months, for a great part of the time twenty hours per day, and the counter of which showed that 193,890 welds had been made with it. He also examined another wire welding machine at the Trenton Iron Works (Messrs. Cooper, Hewitt, & Co.), which had done about nine months' work, and had made 22,095 welds, and at the same works a portable machine, recently installed, which had made 9,022 welds. This last machine was so arranged that it could be carried about easily by two men, and connected with the mains at any part of the immense shop in which it was placed, so as to be used for mending or other welding, wherever required, without the necessity of bringing a heavy coil of wire to it. The managing partners of both the works spoke in the highest terms of the efficiency of the machines, and as to the great saving caused by their perfect utilization of short lengths and broken wires. The welding of brass and copper wire, especially the latter, naturally presented much greater difficulties than that of iron wire, but those seem now to have been overcome. Mr. Kennedy saw at the works of Messrs. Wallace & Sons, in Ansonia, a welder for this purpose, which was one of the first machines put down, and had made 30,415 welds (by register) during the last thirteen months in copper and brass wire; the latter, in

certain cases, of the very hard and poor quality used for making pins. It was at the time being used for welding coils of brass wire into continuous mile lengths (twelve coils to the mile length). The wire was about an eighth of an inch in diameter, and of a very good quality of brass.

Mr. Kennedy had five short pieces of the brass wire welded together into a length of about 18 inches and the burrs removed (the whole operation only taking four or five minutes), and then took the welded pieces to the wire-drawer and had it passed six times through the dies, reducing its diameter from .12 of an inch to .031 of an inch. The existence of the four welds made no difference whatever in the drawing, which was continued until the diameter was reduced to about .002 of an inch.

In order more thoroughly to examine the conditions of straight butt welding in ordinary sections, he made a number of experiments at Lynn. In these experiments, as it was impracticable to measure the power going to the dynamo, he measured the net electrical power going to the welder, and also the exact time during which the current was supplied to the welder. These measurements were made on 25 pieces of wrought iron and steel bar of diameters varying from half an inch to two inches. No sensible difference between the iron and the steel in respect to power or time was found. The horse-power required varied, of course, according to the duration of the operation, and it has been found convenient to make this duration vary directly in proportion to the diameter of the bar, taking forty seconds as the standard time for an iron bar of one inch diameter. Keeping to these conditions, the horse-power per square inch of material remained very nearly constant for bars between half an inch and an inch and a half in diameter, its average value being 20.8. This corresponds to about 30 indicated horse-power at the steam-engine per square inch of welded section during the time that the current was on. This power can be very largely reduced without detriment to the weld, if the saving of power should be of greater importance than the saving of time. Of course, with slower working, the quantity of work which a machine will turn out is proportionately decreased.

The Thomson welders have been used for brazing as well as welding. At the immense bicycle-works of the Weed Sewing-Machine Company in Hartford, Conn., Mr. Kennedy found a brazing welder which had been at work about nine months, and which had made, by register, 29,800 separate operations. The managing director of the works said that he was now modifying the design of his bicycles throughout, with the special object of brazing or welding electrically as many joints as possible.

Inquiries were made as to the wages paid to the men who worked the welders at the different factories visited, and it was found that in no case had highly skilled labor been found necessary.

In summing up the whole matter, it may be said that the Thomson electric welding process has already, in America, been carried fairly beyond the experimental stage, and has achieved sufficient success in regular commercial work of somewhat varied kinds to warrant the belief that its industrial future is one of the greatest practical importance.

The process of welding in use by the Thomson Electric Welding Company has been fully investigated also by a United States naval board, consisting of George A. Converse, A. S. Greene, S. W. Armstead, and Gilbert Wilks, which convened at Boston, Feb. 10. They find that at the present time this process renders it possible, practically, to weld wrought-iron, cast-iron, brass, and copper rods from the size of the smallest electrical conductors in use for distributing purposes, to rods of two and a half inches diameter, and to weld pipes of larger sizes; to weld dissimilar metals, and pieces of different forms of cross-section; to join by welding the ends of wire cables, and to form welded rings of small or large diameter.

The board is "convinced that the Thomson welding process can be found of great utility to the naval service, both on shore and afloat, for the following reasons: it can be used (*a*) in welding breaks in rods without altering them either in length or shape; (*b*) for welding tubes; (*c*) for welding angles and shapes of intricate form; (*d*) for welding copper, brass, cast-iron, or other metals; (*e*) for heating metals for forging, tempering, and upsetting; and (*f*) for welding wire cables."

HEALTH MATTERS.

Consumption in Hayti.

THE natives of Hayti believe phthisis pulmonalis, according to Dr. R. P. Crandall (*Medical Record*, Jan. 11, 1890), to be both contagious and infectious, and fear it much more than yellow-fever or small-pox.

A native who is believed to be affected with this disease is avoided and shunned by all who know him, and becomes an object of prayer for the priests, and of pity for the people.

When a consumptive dies, the entire contents of the room in which he died are either destroyed or thrown into some place set aside by the government for that purpose. This sacrifice of property not only includes the furniture of a room, but also articles of value, such as jewelry, gold, and precious stones. This idea of destruction is carried to such an extent by some, that the paper is sometimes removed from the walls, and the floors torn up. Cases have even occurred where small houses, in which deaths from phthisis have taken place, were burned down to the ground to prevent the spread of disease.

"While riding one day near the suburbs of Cape Haytien, the commercial capital of northern Hayti," writes Dr. Crandall, "I came across a sort of marsh or land of mud known as the Cimetière des Chevaux. Scattered over its surface, and half sunk in its muddy depths, were innumerable household articles, furniture of all kinds, sewing-machines, pianos, book-cases, books, etc. Here and there also appeared the whitened skeletons of animals. My curiosity being excited, I asked of a native standing near the reason for this apparent waste of property. He informed me that the Cimetière des Chevaux was a repository for the dead bodies of anmials, and for every thing that was found in the room of one who had died from *la poitrine* ('consumption'). When asked if any thing was ever removed from the cemetery, he answered that nothing would induce a Haytien to even touch any thing that had been placed there. I found this to be strictly true, as on several occasions I offered natives sums of money to bring me articles from the cemetery, and was always refused with looks of horror and repugnance. On careful investigation, I found that phthisis was regarded as contagious by all classes throughout Hayti."

THE HOUR AT WHICH DEATH OCCURS.—From a study of fifteen thousand cases, extending over a period of twelve years, Dr. J. F. Burns states, in the *New York Medical Journal* for Jan. 4, 1890, that it would appear that death occurs seemingly without any particular predilection for any certain hour, and that the number of deaths for each hour is very evenly proportioned, considering the large number of cases taken and the time covered. The only very positive conclusions the author has formed from the figures are (1) that the idea that more deaths take place in the early morning hours is an erroneous one; (2) if stimulants are to be pushed in disease during these hours, the practice must be justified upon some other ground than to avert the possibility of danger supposed to be very probable at this period; (3) that the vitality of an individual in disease is not regulated by the same influen es or subject to the same laws that govern the vitality of a healthy human being, the normal equilibrium maintained in health between the mental and physical states being altered.

PUTREFACTION AT GREAT DEPTHS IN THE SEA.—Dr. Regnard has raised the question, says the *Bristol Medical Journal*, as to whether a corpse which sinks to a very great depth is preserved indefinitely or otherwise from putrefaction. According to his researches, published in the archives of the Biological Society of Paris, putrefaction does not take place in decomposable substances submitted to a pressure of 600 to 700 atmospheres. These figures correspond to a depth of 6,000 or 7,000 metres at sea. From these experiments it must be concluded, according

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—The annual report of the trustees of the Lenox Library shows that there has been no change in the condition of the library since their last report to the Legislature. A re-arrangement of the various collections of which it is composed, begun during the year and still in progress, was determined on by the trustees with a view to its easier administration in the service of the public, who are freely admitted to its inspection and use. The total number of visitors in 1889 was 8,708. An addition of special interest has been made to the picture-gallery in the gift, by Mr. Alexander Maitland, of the portrait of Van Brugh Livingston, by Sir Henry Raeburn. The chief additions to the other collections have been made by the purchase of the library of the late president, Robert Lenox Kennedy. The Drexel Musical Library, the legacy of the late Mr. Joseph W. Drexel, has been completely arranged in special cases. The completion and publication of the catalogue, which is now in progress, will make available to the musical world what is perhaps the most important collection of the kind in this country.

—An interesting paper by Major Rogala von Bieberstein, German Army, has appeared in the February number of *Colburn's United Service Magazine*. The principal deductions derived from the last summer (1889) manœuvres in the presence of the Emperor, when "extensive use was made of smokeless powder by different divisions of the Guards, as well as by the whole of the Tenth Army Corps," may be summarized as follows. Cast-steel guns were seriously injured; bronze guns were unaffected; steel-bronze guns are recommended. It was found necessary to lubricate gun-barrels from time to time by means of an oily cloth. The cartridges take up less space in the powder-chamber. Whether with guns or rifles, "a better aim is obtained, as also quicker firing; it is easier to judge distances; a better view of one's own troops is obtained; a clearer general view is presented; and a better control in directing an attack or defence is practicable. . . . Troops can suffer great losses from an enemy's fire without knowing whence it comes, and whither they shall direct their fire in defence. . . . The artillery. . . will in future fill their shells with explosives which produce dense smoke, in order the better to observe the" bursts. "Cavalry will suffer more than any other branch of the service by the introduction of smokeless powder, for their best friend was always the smoke which veiled their attack. . . . Their tactical worth in field operations will become much less" than formerly. As to the defence, defenders "can use their weapons with more composure, especially in the front line, than can the attacking party. . . . The spade will play a more important part than formerly, as well for the infantry as for the artillery." As regards the attack, the cavalry will reconnoitre a position under great difficulties, they "must be prepared to suffer . . . greater losses than heretofore," and "must develop a more careful reconnoitring activity. . . . The attacking party of to-day must make great use of his artillery to shake the enemy's infantry" before the position is assaulted. Major Bieberstein considers that the "attacking force which leaves its cover to advance will be cut down by a murderous fire, better aimed than formerly. . . . The increased deadly effect of the repeating rifle and smokeless powder on an enemy repulsed after an unsuccessful storm, will tend to annihilation, and probably change an orderly retreat into hopeless flight." Applying these deductions, it appears more than ever necessary that generals in the field should be experts of the highest order. Also it appears that the preponderance of advantages gained by modern inventions lie with the defence, and that troops which may not possess sufficient experience to attack, may nevertheless defend a good position against the best soldiers in the world, and especially in an enclosed country.

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—An interesting paper by Major Rogala von Bieberstein, German Army, has appeared in the February number of *Colburn's United Service Magazine*. The principal deductions derived from the last summer (1889) manœuvres in the presence of the Emperor, when "extensive use was made of smokeless powder by different divisions of the Guards, as well as by the whole of the Tenth Army Corps," may be summarized as follows. Cast-steel guns were seriously injured; bronze guns were unaffected; steel-bronze guns are recommended. It was found necessary to lubricate gun-barrels from time to time by means of an oily cloth. The cartridges take up less space in the powder-chamber. Whether with guns or rifles, "a better aim is obtained, as also quicker firing; it is easier to judge distances; a better view of one's own troops is obtained; a clearer general view is presented; and a better control in directing an attack or defence is practicable. . . . Troops can suffer great losses from an enemy's fire without knowing whence it comes, and whither they shall direct their fire in defence. . . . The artillery. . . will in future fill their shells with explosives which produce dense smoke, in order the better to observe the" bursts. "Cavalry will suffer more than any other branch of the service by the introduction of smokeless powder, for their best friend was always the smoke which veiled their attack. . . . Their tactical worth in field operations will become much less" than formerly. As to the defence, defenders "can use their weapons with more composure, especially in the front line, than can the attacking party. . . . The spade will play a more important part than formerly, as well for the infantry as for the artillery." As regards the attack, the cavalry will reconnoitre a position under great difficulties, they "must be prepared to suffer . . . greater losses than heretofore," and "must develop a more careful reconnoitring activity. . . . The attacking party of to-day must make great use of his artillery to shake the enemy's infantry" before the position is assaulted. Major Bieberstein considers that the "attacking force which leaves its cover to advance will be cut down by a murderous fire, better aimed than formerly. . . . The increased deadly effect of the repeating rifle and smokeless powder on an enemy repulsed after an unsuccessful storm, will tend to annihilation, and probably change an orderly retreat into hopeless flight." Applying these deductions, it appears more than ever necessary that generals in the field should be experts of the highest order. Also it appears that the preponderance of advantages gained by modern inventions lie with the defence, and that troops which may not possess sufficient experience to attack, may nevertheless defend a good position against the best soldiers in the world, and especially in an enclosed country.

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encounter, I may commence by giving an account of the rain theories which have been popularly adopted by meteorologists. These have been condensed in the following words by Mr. Scott:—

"Rain is produced by the chilling of air more or less charged with moisture. This is effected in various ways, of which the following are the principal: No. 1. The ascent of a current of damp air, which is chilled as it rises; No. 2. The contact of warm and damp air with the colder surface of the ground, as in case of our own west coasts in winter [England], where the land is colder than the sea-surface; No. 3. The mixture of masses of hot and cold air."

In the first place, it seems strange that rain should be caused by the chilling of the atmosphere, as rain is almost invariably accompanied by milder weather. A certain type of mild weather is nearly always the forerunner of rain. During the rain the temperature hardly sinks, although the sun is prevented from shining on the ground; and we generally expect warmer weather to follow after the rain. These remarks may serve to rouse suspicion against the theory of rain being caused by chilling, for we may feel perfectly sure that any theory which goes straight against the general weather indication must be wrong from the outset. However, let us now examine the theory in detail.

Of these three causes, No. 3 is by the author himself placed *hors de combat*, when he states that Dr. Haun of Vienna has calculated, "that even by assuming a very extreme case, which could hardly occur in nature, there could not be produced as much as the twentieth part of an inch of rain."

Cause No. 2 is by the author partly included in cause No. 1, as the sloping land-surface causes the air moving against it to ascend. As to the other part of it, I fail to see how contact between a cold surface and warm air can produce rain. It can produce deposit of dew, as, for instance, when we bring a glass of cold water into a heated room; but rain always falls from a considerable distance from the ground, and is therefore not created at the place of contact of the air with the land-surface.

We are therefore now reduced to cause No. 1 as the only possible cause of rain. This is, however, worse than any cause at all, as may be seen from the following simple and well-known experiment. If, under the piston of a strong glass cylinder, we have air saturated with moisture, and press the piston down, a portion of the moisture is condensed into water, as is seen by the mist formed, and the trickling of dew down the inner surface of the glass vessel. The temperature is raised by the compression, but not sufficiently to prevent condensation from taking place. If we now draw the piston back to its first position, we find the air under the piston in the same condition as when we started the experiment. But this means, that, by expanding the air, the moisture which was condensed into water by the compression has again evaporated. The air, therefore, gets chilled by the expansion, but not sufficiently to prevent this evaporation from taking place.

The consequence is, that the chilling produced by expansion during the ascent of a current of damp air can under no circumstances cause condensation of its moisture into rain. The experiment, however, shows that condensation or rain can be produced by a body of saturated air being brought under greater pressure; and of this we will just make a passing note.

The modus or the ascent of a current of damp air is by most meteorologists considered to be the chief cause of rain, and is supposed to take place at the centre of a cyclone. It is thus maintained that there is a certain inward movement of the circulating surface-air in a cyclone, and that for the air (this is supposed to be always damp air) which is carried by it towards the centre there is no other means of escape but to rise at the centre. How absurd this whole explanation must appear to anybody who has been living in deserts or arid districts, will be observed when I mention, that, while I was in Australia during a period of very severe drought, a break in the drought was caused by a series of cyclones crossing the country,[1] entering in the northern part of New South Wales, and passing out again through Victoria, thereby drenching a narrow strip of land about 50 miles wide and 400 or 500 miles long with rain, while on both sides the drought continued uninterruptedly. It seems difficult to explain how this cyclone should have gathered its supply of moisture from moisture rising from the dry surface-air over a perfectly dried-up country.

[1] See H. C. Russel, Report on Rainfall of New South Wales.

What we want is evidently a rain theory which is capable of accounting for rain, whether the surface over which a cyclone passes is wet or dry, or whether it is giving off vapors or not; and I have taken pains to show how utterly incapable the existing theories are in this respect, so as to clear the atmosphere from old cobwebs which might stand in the way of an entirely different view of the whole question, being well aware of the opposition with which new theories are generally met at the beginning.

In my pamphlet on drought I called attention to the aqueous vapor as the element of the atmosphere to which some unknown quality was likely to adhere, and by knowing which we should be able to explain the whole atmospheric puzzle. With the object in view of finding this secret, I undertook in April, 1888, a series of observations from the tower of the Rouen Cathedral in France.

The object of these observations was to ascertain the difference in barometrical pressure existing between the two ends of a vertical air-column, and to observe how far and in what manner this difference, or the weight of the air-column, changes when the state of humidity of the air varies. At the base and top of the steeple of the cathedral, which is upwards of 500 feet high, was established a station containing quicksilver barometers (and aneroid barometers to check the readings of these) and dry and wet bulb hygrometers. At convenient places between the two stations, thermometers were hung out with the object of attaining a fair average of the temperature of the air-column.

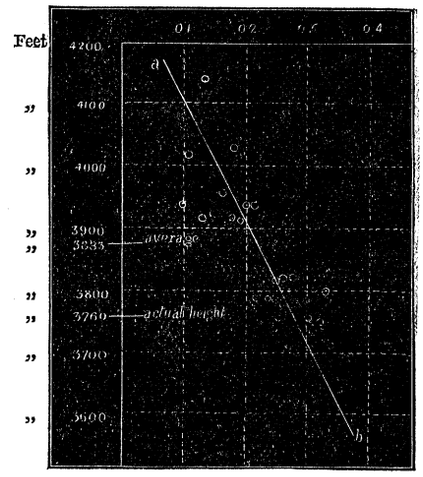


FIG. 1.

The two stations were connected with a telephone; and at convenient hours, at any time during the day or night, for a period of about fourteen days, synchronous readings of all instruments were taken at both stations.

The instruments were the best and newest made by Messrs. Negretti and Zambra of London, and were all adjusted at the Kew Observatory. It is my pleasant duty to mention here that this well-known firm of instrument-makers wrote me a polite letter, in which they offered the loan of their instruments free of charge, considering the interest involved in my researches. To assist me in making these observations, I secured the services of Mr. McClellan of the Greenwich Observatory, who has had many years' experience in handling the most delicate meteorological instruments.

Thus every thing possible was done to obtain reliable observations, and the result was as stated below. Instead of reproducing here the figures of my own personal observations, I think it will be more to the purpose to point out how the same result can be

distinctly traced in the observations made by others, who at the time were not aware that these results could be deduced from their observations.

As such, I have selected Professor S. P. Langley's "Professional Papers, Signal Service, No. XV., War Department, U.S." On p. 191 is a table showing the results obtained by measuring the altitude between sea-level and Lone Pine, Mount Whitney. Of these forty measurements, I have in the following table given the ten highest (upper half of table) and the ten lowest (lower half), arranged according to the height.

Table of Barometric Measurements of Altitude between Sea-Level and Lone Pine, Mount Whitney.

Time of Observation. 1881.	Results in Feet.	Weight of Vapor in Inches of Mercury.	At Lone Pine.	
			Relative Humidity.	Temperature, Fahrenheit.[1]
Aug. 26, noon	4,140	0.1354	10.3	87.8°
Aug. 26, 9 P.M.	4,030	0.1823	28.8	65.7°
Sept. 3, noon	4,020	0.1060	8.7	85.4°
Aug. 29, noon	3,960	0 1627	15.6	80.6°
Aug. 25, noon	3,940	0.2081	18.1	83.6°
Sept. 3, 9 P.M.	3,940	0.0960	13.5	69.1°
Aug. 24, noon	3,940	0.2158	16.0	88.6°
Aug. 17, noon	3,920	0.1782	14.9	84.6°
Sept. 2, noon.	3,920	0.1302	9.9	87.8°
Aug. 24, 9 P.M.	3,915	0.1931	29.0	67.2°
Aug. 20, 9 P.M.	3,820	0.2787	35.5	72.0°
Aug. 19, noon	3,820	0.2615	17.8	91.3°
Aug. 23, 9 P.M.	3,815	0.2508	38.3	66.7°
Aug. 18, 9 P.M	3,800	0.3314	78.0	54.7°
Aug. 31, 9 P.M.	3,790	0.2190	45 7	57.6°
Aug. 30, 9 P.M	3,790	0.2352	53.1	55.6°
Aug. 27, 9 P.M.	3,760	0.2543	68.0	51.0°
Aug. 21, 9 P.M.	3,760	0.3034	38.4	72.2°
Aug. 22, 9 P.M.	3,750	0.3232	70.1	56.7°
Aug. 19, 9 P.M	3,710	0.3405	71.5	57.6°
Sept. 7, 9 P.M.	3,625	no record		
Sept. 6, 9 P.M	3,620			

[1] The ten highest give an average of 80° F.; the ten lowest, 63° F.

Alongside of each of these figures will be found a number representing the weight of vapor per unit of volume contained in the atmosphere at the time of observation. These latter numbers are obtained by multiplying the relative humidity at Lone Pine (see table in Langley, p. 177) by the elastic force of vapor (Glaisher's tables).

The difference between the maximum and minimum result is 520 feet, or 14 per cent of the trigonometrically surveyed height, 3,760 feet. This latter number was obtained by the engineers who built the railroad passing Lone Pine. Langley's party wrote to the engineers for this information, and awaited their reply with considerable anxiety.

From the table it will be noticed that the amount of vapor in the atmosphere was considerably less when the ten highest results were obtained than when the ten lowest were obtained; and, as perhaps may be better illustrated by the accompanying diagram (Fig. 1), there appears to be an unmistakable relation between the measured heights and the humidity of the atmosphere. The heights are here placed at distances from the vertical line to the left proportional to the amount of vapor in the air, and the line *a b* shows the general tendency of the figures. That these do not follow the line *a b* more closely, may be accounted for by the humidity of the air having been measured only at one end of the air-column; namely, at Lone Pine. This seems to prove the greater buoyancy of cold vapors compared with warm.

We may, however, trace another coincidence in our table. It will be noticed that the ten highest results are generally from observations taken at noon, when the thermometers showed a relatively high temperature, while the ten lowest results are all (except one) from observations taken at 9 P.M., when the temperature was considerably less This is only what we might have expected, and shows that the buoyancy or tending upwards of the vapors in the atmosphere is considerably greater at a lower temperature than at a higher, as explained elsewhere.

Professor Langley's observations give results corresponding to those I obtained at Rouen, and the relations here pointed out may be traced in numerous works from ancient and modern times, though perhaps not in all. However, it should be remembered that it is not so much my present purpose to show how the measurement of altitudes by means of barometers may be carried out with greater accuracy than hitherto (this method being highly unsatisfactory for obvious reasons) as to show that the hidden agencies which are at work in the atmosphere, and without assuming which the whole atmospheric problem remains unsolved, may be distinctly traced in the observations carried out by others. Surely we must expect to find the secrets well concealed, or they would have been demonstrated ages ago; but here, as elsewhere, it is the instances when "the sky is unobscured by clouds," to use a figure of speech, which we must select to make our observations, and Langley's table is such an instance

The results of my experiments above referred to showed that an air-column 150 metres high, between the top and base of this tower, became 1.3 per cent lighter by an increase of atmospheric humidity, indicated by an increase of elastic force of vapor of from .2 to .3 of an inch pressure. The temperature was reduced to 40° F., and the atmospheric pressure to 30 inches.

According to Glaisher's "Hygrometrical Tables," one cubic foot of dry air at 40° F. at a pressure of 30 inches, weighs 557.8 grains, while one cubic foot of saturated air weighs 556 grains. The difference, 1.8 grains, is about .0033 per cent of the whole weight. The dry air, by becoming saturated, has therefore suffered a loss in specific gravity of .0033 per cent, or, what is pretty nearly the same, it has been expanded .0033 per cent.

According to my observations at Rouen, the loss in weight would, under similar conditions, have been 3.2 per cent, or ten times greater than shown by the tables.

How are these seemingly contradictory results to agree? The method of taking the weight of a certain volume of air confined in a vessel, by which the tables have been computed, is eminently adapted to give us the exact specific gravity; and the experiments have been repeated so often by excellent observers that we have no reason to doubt their correctness. If, therefore, we take it for granted that only one-tenth of the loss in weight sustained by the open column of air was due to expansion, the rest, or nine-tenths, must have been due to the buoyancy[1] of the aqueous vapors, which would carry a part of the weight of the air-column; and this force could under no circumstances have shown itself under the experiments with air in confined vessels, whose absolute weight is taken in a vacuum.

We have hereby been able to demonstrate the buoyancy of aqueous vapor in the atmosphere as a force that must influence the readings of the barometer very considerably, and we now understand fully why the readings of the barometer are lower when the atmosphere is moist than when it is dry, as in an anticyclone or air-cushion, simply because the greater amount of vapors in the moist air carries a greater portion of the weight of the air-column overhead than when the air is in a dryer state.

The atmosphere being a perfect mechanical mixture of air ($O+N+CO_2$) and aqueous vapor (H_2O), the buoyancy of the latter must mainly depend upon the difference in specific gravity between the vapor and the air by which it is surrounded; and

[1] See my paper, "On the Cause of the Diurnal Oscillation of the Barometer," in Engineering, London, Jan. 11, 1889.

we will now examine how this changes for different temperatures and at different levels. The following table is gathered from Glaisher's "Hygrometrical Tables" (IV. and VI.) :—

Weights in Grains of One Cubic Foot, at 30 Inches Pressure.

Temperature, Fahrenheit.	Dry Air. (a)	Vapor. (v)	Ratio. $\frac{a}{v}$
0°	606.4	0 55	1,000
10°	593.4	0.84	700
20°	581.1	1.30	447
30°	569.2	1 97	300
40°	557.8	2.86	200
50°	546.8	4.10	133
60°	536.3	5.77	91
70°	526.2	8 01	66
80°	516.4	10 98	47
90°	507.0	14.85	35
100°	497 9	19 84	20

It will be seen from this table how much lighter vapor is than air, and that the difference in specific gravity is highly increased as the temperature sinks. While air follows Gay Lussac's law by expanding by heat and contracting by cold, the vapor follows a law the reverse of Gay Lussac's by contracting by heat and expanding by cold, but at a much greater rate for equal temperatures: $\frac{v}{a}$ gives us the specific gravity of vapor, that of the surrounding air being 1; it shows how the buoyancy of vapor $\left(\frac{a}{v}\right)$ is strongly increased as the temperature sinks. At 100° the specific gravity of vapor is one-twentieth of that of the surrounding air, and at 0° it is only a thousandth part of it. The weights are measured under a pressure of 30 inches, the pressure at the earth's surface. To find the weights at higher levels, where the pressure is less, we have only to multiply the numbers of columns (a) and (v) with the same factor according to Marriott's law. As $\frac{v}{a}$ hereby remains unchanged, it appears that the buoyancy of vapor in the atmosphere depends entirely upon the existing temperatures, and is independent of the pressure, or the level at which the vapors are found. As the temperature constantly sinks as we rise in the atmosphere, the buoyancy of vapor, or the force with which vapors tend upwards as they rise to higher levels, is constantly increased, and at an astonishingly high rate. While, therefore, the speed with which vapors rise in the atmosphere may be more or less imperceptible at the ordinary temperatures at the earth's surface, it is rapidly increased as the vapors rise, and may attain an almost inconceivable magnitude in the extreme cold which exists at a great distance from the earth's surface.

With the results deduced from the table fresh in our mind, we may now draw a picture from nature while trying to follow the vapors on their upward passage through the atmosphere, and we shall see how far our calculations agree with the natural phenomena. To take a distinct case before us, let us suppose that on a fine day, with high barometer, we are in a dry locality in which is found an isolated swampy place or lake (Fig. 2). While the surface-air is dry generally, we find it moister over the swampy place, as the sun and the warm and dry air which passes over it cause a strong evaporation to take place. The warm surface-air, though expanded by heat, moves over the ground without rising. It is first caused to ascend by being intermixed with the vapor-particles. According to their buoyancy, the vapor-particles tend upwards through the atmosphere, thereby carrying the air with which they are intermixed upwards also, and the ascent of a current of damp air is established. The vapors are the real cause or life in this motion, each and all of its particles acting as so many minute balloons. Some eight or ten thousand feet overhead, perhaps at a little distance laterally from the moist ground, according to the direction in which the air moves over the ground, we notice an enormous cumulus-cloud being formed, and we have no doubt whatever that it is caused by the current of damp air ascending from the moist piece of ground. The ascending current, after having passed through the heated surface-air, gets suddenly into a much colder stratum, and condensation takes place by mixture of the rising damp air with the cold air it is passing through. As a rule, the chilling caused by the expansion of the ascending current gives it a temperature pretty nearly the same as that of the air through which it passes. It is only when it is met by a sudden change in the temperature of the surrounding air that condensation takes place by mixture, which we may express by saying that the ascending current has "caught a cold." Instead, therefore, of it being the chilling by expansion which causes condensation into clouds and thereby rain, we see that it is a fact that the chilling was not sufficient when the ascending current was taken by surprise by the sudden change in temperature If the colder stratum of air be moving along, we may notice a row of detached cumulus-clouds at some distance from the one nearest to the moist piece

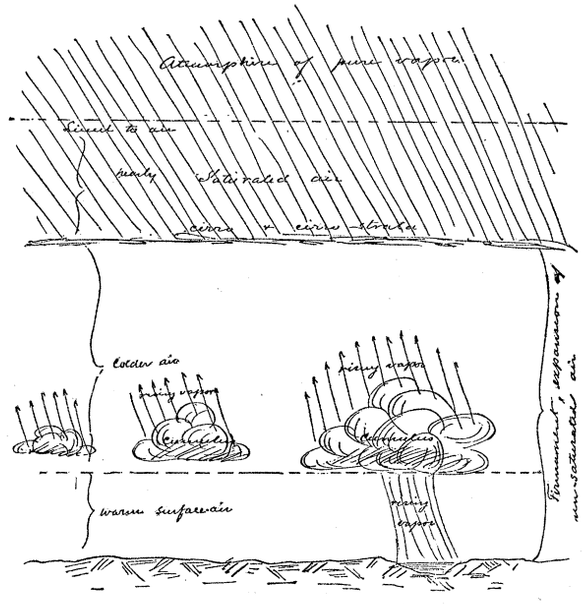


FIG. 2.

of ground, but they grow smaller and smaller the farther away they pass. They are thus cut off from the supply of damp air, and being surrounded by unsaturated air on all sides, and exposed to the sun's rays, they rapidly evaporate.

The formation of these cumulus-clouds was therefore only a passing event in the ascent of the current of damp air; and as the vapors rose before they were condensed, so they will rise again when they are turned into invisible vapor again, and the more quickly, the faster the temperature sinks during the ascent. While, therefore, air and vapor are equally expanded by decrease of pressure during ascent, the decrease of temperature acts differently upon them, having the effect of contracting the air, while the vapors are very much expanded. For both these reasons the buoyancy of the vapor is increased during the ascent. The vapors must therefore necessarily rise as long as there is any air to pass through, unless they meet with a layer of saturated moisture, or air saturated with moisture.

The clouds produced by the ascent of a current of damp air are cumulus-clouds, and they resemble in their shape very much the mist caused by steam escaping from a chimney. The phenomena are, in fact, precisely similar; and the cumulus-clouds are in their nature as unstable a product as the mist from a chimney, only the first phenomenon is on a much larger scale, and consequently it takes a much longer time for the cumulus-clouds to evaporate.

The formation of this class of clouds has, however, had a very disturbing effect upon the conclusions arrived at as to the cause of rain, particularly as they are not absolutely rainless, but occasionally give a shower of rain. A shower, however, is a distinct case, which has nothing in common with the great rain, day's rain, or cyclone-rain, capable of yielding eight to ten inches of rain *per diem*.

To continue our sketch from nature, at a considerable distance overhead we will generally on such a fine day, notice some extremely thin and airy clouds,—the so-called mare's-tails, cirrus, or cirro-stratus. The sky is often suddenly changed from a perfectly cloudless one to one completely covered by a thin layer ("pallium," or cloak, as it has been called) of clouds; and records show that not only has it been the case with the small part of the sky we can observe from one place, but that the sky has been suddenly covered by these clouds far and wide for thousands and thousands of square miles.

As to the height at which these clouds are found, I have particularly asked Mr. Glaisher, who is famous for his wonderful balloon-ascents. He told me that he had gone up five and six miles, and passed through other clouds, but he never seemed to get any nearer to the cirrus-clouds. He even went up seven miles; but then he became senseless, and unable to observe any thing. To estimate their height at thirty or forty miles seems, therefore, hardly to be an exaggeration.

What is the cause of these clouds, and where do they get their supply of vapor to keep them permanent often during the whole long day in the face of the shining sun? As they are strata-like, and entirely different in their shape from cumulus-clouds, we may feel certain that they are not, like the cumulus-clouds, caused by the ascent of damp air. But if their supply of vapor

FIG. 3.

a, moist air; *b*, rotating body of surface-air.

is not to be found below them, it must be on the other side of the strata, or above them. The occurrence of cirrus-clouds is therefore an unquestionable proof of the existence of a uniform layer of saturated air at an exceedingly high level.

Our table has shown us clearly where the invisible vapors must go to, and the cirrus-clouds now show us where they are stored up at a great distance from the earth. Our only difficulty now is to explain how the vapors are brought down from this high level, or how they become condensed into clouds and rain. For all we know, a cyclone is a body of surface-air brought into rotary motion, and the effect of this rotation is that rain occurs, if anywhere, at or towards the centre of the rotating body of surface-air; and this takes place whether the cyclone passes over the sea, over moist ground, or over dry land. The centrifugal force sweeps the surface-air from the centre of the cyclone. The partial vacuum which is thereby produced can only be filled up by the descent of the air or vapor above the rotating body of surface-air. This is thereby brought under greater pressure; and, as the experiment referred to above shows that condensation or rain can be produced by compression, we have hereby arrived at a possible explanation of cyclone-rain. This theory agrees with such a general observation as that the clouds are at their lowest level when rain comes from them.

In agreement with this compression theory, we may explain the prevalence of rain on the rising slope of coast mountains, or mountain-ridges in general. While rain falls at the centre of a cyclone, the sky at some distance from where the rain falls is in a condition not far from giving off rain, and so the extra pressure brought to bear upon this saturated air by meeting an obstacle, such as a mountain-ridge, causes rain to set in.

The sketch may represent in section a mountainous coast, against which the moisture-laden clouds are driving from out at sea. The current of air, by meeting this obstacle, is caused to rise, following something like the course shown in Fig. 4. At *a* there is always shelter during such a gale, as shown by the sheep and cattle which gather there. In other words, the current rises to its maximum height at *b* above the inland slope of the mountain. Consequently that is where, according to the theory I am opposing, we should expect the greatest downpour; but there is generally next to none, while the rain nearly all falls on the front side of the mountain. At *c* the current is forced out of its horizontal direction, but a force can only be communicated to an elastic body like air by compressing it. The rain has therefore been caused by compression of saturated air.

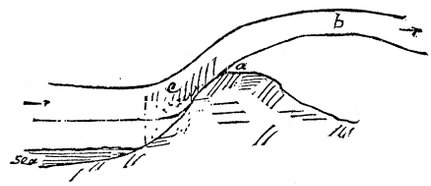


FIG. 4.

Fig. 5 represents a section of the atmosphere of the southern hemisphere for the month of July, the section being made through the Tropic of Capricorn (see map in my paper, "On the Cause of Trade-Winds"). The intersected parts of the three southern continents are at that time of the year in a dried-up state, and the air-cushions which consequently develop over their surfaces are thrown westwards over the oceans. The height of the vapor atmosphere over the surface of the earth is varying and at its maximum in the anti-cyclones. If we should imagine for a moment that there is no surface-evaporation, or that the earth is

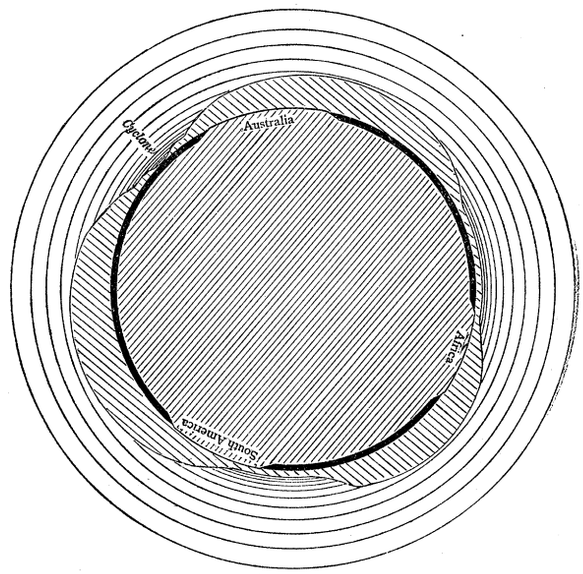


FIG 5.—IDEAL SECTION OF ATMOSPHERE AT THE TROPIC OF CAPRICORN.

(The circles indicate the outer atmosphere of invisible vapor.)

perfectly dried up, the dry air would arrange itself in a uniform layer between the earth and the vapor atmosphere as a continuous air-cushion of uniform thickness, and there could be no possibility of rainfall. The tendency of the vapor atmosphere is towards such a regular shape, but this tendency is counteracted by the varying degree of evaporation at different parts of the earth's surface. A strong surface-evaporation has the effect of decreasing the height of the vapor atmosphere over the surface of the earth, while little or no surface-evaporation has the opposite effect. In the space between the anti-cyclones the height of the vapor atmosphere over the ground is comparatively small, and it reaches a minimum when (say, for instance, in the V-depression between two anti-cyclones) the surface-air is, by the currents of opposite directions along the borders of the anti-cyclones,

brought into rotary motion, which drives the surface-air away from a centre. The vapor atmosphere is thereby caused to approach the earth's surface, and by thus descending is brought under greater pressure, so as to give off rain at the centre of the cyclone, as explained above.

Having, by a simple way of reasoning, arrived at the conclusion that an atmosphere of pure aqueous vapor must exist outside the atmosphere proper, we should not feel justified in stopping without carrying our idea out in at least some of its consequences, although the following remarks do not concern our immediate subject, the cause of rain. Supposing there was an outer limit to this aqueous atmosphere, the difficulty which would present itself is, that we should find aqueous vapor alongside of the vacuum of space. It is well known that when moisture is brought into an artificially produced vacuum, the latter gets instantaneously filled with aqueous vapor. How is this experiment to agree with the popular notion that vapor, as well as the other constituents of the atmosphere, is kept within limits round the earth by means of gravitation? If the vapors of the supposed outer border of the atmosphere were prevented from entering space owing to gravitation, how much more would the vapors at the bottom of an artificial vacuum be prevented from filling this space, as the force of gravity is much the greater at the earth's surface than at a supposed outer border of the atmosphere?

Surely, we must conclude that it is impossible to imagine how moisture could remain in the air or on the earth's surface, unless space were filled with aqueous vapor. The earth's surface being practically that of a huge drop of water, and this drop moving round the sun in a supposed vacuum, how could this moisture be prevented from escaping into space unless space was filled with aqueous vapor? The only thing to prevent such an emergency is the thin veil of an atmosphere; but this, being itself all permeable and permeated with aqueous vapor, seems indeed a very poor protection.

Laplace's nebular theory of the evolution of the solar system points towards the same fact; for, if aqueous vapor has once been uniformly dispersed throughout the solar space, it follows of necessity that this space could not afterwards have become perfectly exhausted of aqueous vapor: gravitation towards the sun and the planets could not establish such a vacuum.

If it should be used as an argument against my theory, that we might with just as much right expect to find the other constituents of the atmosphere dispersed through space in a rarefied state, then I would say, as has been pointed out above, that these follow the reverse law of aqueous vapor by being contracted by cold, and that makes all the difference.

The general conclusion I arrive at is, therefore, that the interplanetary space is filled with vapor in an extremely rarefied state. The sun and each of the planets is surrounded by a vapor atmosphere of a denser state, the quantity of vapor surrounding each of these bodies depending upon its size and its surface-temperature. The sun will for both reasons have by far the lion's share of such a vapor envelope. This theory seems to agree perfectly well with the following observed facts:—

1. The retardation suffered by the comet Encke indicates that this comet, when nearest to the sun (that is, at a distance from the sun about that of Mercury), passes through a medium of a certain resistance.

2. The present condition of the surfaces of the four inner planets varies according to their distances from the sun, or, what is likely to be in proportion thereto, their surface-temperatures. On Mars we find more land than water surface, and a clear sky. The conditions on the earth in this respect need not be repeated here. As to Venus and Mercury, they possess an atmosphere of great density; and, as they are constantly covered by clouds, we have no means of ascertaining the proportion between land and sea surface, but their clouded state seems to indicate that they must be entirely or almost entirely covered by water. These varying conditions seem to indicate that the planets are gradually approaching a state of being dried up, or that their waters and vapor envelope are gradually leaving them; and the conditions on the moon indicate that this state will have been reached when they have become extinct planets.

3. The moon being an integral portion of the earth, there can be no doubt but it must once have possessed surface waters and a vapor envelope in proportion to its size. It is now an extinct planet, and its surface is void of waters. What has become of this water, unless it has passed into space?

We have hereby gained a fresh point of view, from which it may be worth our while to reconsider the former, present, and future conditions on the earth. Geologists have come to the conclusion that at the time of the coal period there must have been much less land surface than now, and that the atmosphere must then have been much warmer and moister than it is now. The land may, of course, gradually have emerged from out the seas since then, the quantity of water on the earth remaining constant; but it seems exceedingly more natural to suppose that the earth contained much more water during the coal period than it now contains. When, therefore, we nowadays find ancient sea-beds in the highest of mountain-ridges, we need not feel so sure that these have risen to their present elevated position from under the present level of the sea, as probably the sea-level was formerly quite different from what it is now.

Mathematicians have at various times attempted to determine the outer limit of the atmosphere by calculating at what distance from the earth there would be equilibrium between the centripetal and the centrifugal forces acting upon the smallest particle of air, thereby arriving at results varying from fifty to two hundred miles, the difficult point being how to determine the actual mass and density of the particle of air. Other philosophers have seen the absurdity of imagining the situation of an air-particle in a state of uncertainty as to whether to remain with the earth or go off at a tangent, and therefore have concluded that the atmosphere is practically unlimited.

Another series of considerations has led to the conclusion that outside the atmosphere of air, which may be estimated at forty or fifty miles, must exist an atmosphere exceedingly thinner than air. These various theories are brought into perfect agreement, and the absurdities are avoided, by assuming my theory of an outer atmosphere of vapor, which is unlimited.

It is truly said that there is nothing new under the sun, and we might therefore expect to find that my definition of the atmosphere is merely a repetition of what has been said at former times. In his excellently written book, Mr. Scott points out that the old biblical scriptures, particularly the Book of Job, contain many a sound reasoning on the atmosphere which holds good to this very day. Not having found the information I wanted in modern works on this subject, I took the hint, and looked up these ancient sayings, until I came to a passage by Moses which made me pause. Perhaps Col. Ingersoll may some day point out some serious mistakes in my argument or in the figures I have produced to support it, but at present it seems rather as if Moses managed to give us a pretty clear definition of the atmosphere when he wrote, "And God said, Let there be a firmament [Hebrew, "expansion"] in the midst of the waters: and let it divide the waters from the waters. And God made the firmament, and divided the waters which were under the firmament from the waters which were above the firmament: and it was so."

The coincidence between this observation of Moses and the result I have arrived at may perhaps, in our advanced age, be considered merely as a curiosity; but, considered as a purely objective and perfectly unbiased view of the matter, it seems to me to afford some further interest. Moses could not argue much on atmospheric subjects, as he had no natural sciences to guide him, but neither could they lead him astray. His knowledge of air was very limited. He did not know that it exerts a pressure of fourteeen pounds per square inch, and that this pressure grew much less when he went on to Mount Sinai to write the Commandments; and neither could he have any knowledge of the existence of invisible vapor. But when he walked about in the desert for forty years under a generally serene blue sky, and on rare occasions saw a cyclone set in, then he would observe this phenomenon exactly as Mr. Scott describes it nowadays: "He saw the thin cirro-clouds overhead gradually change into stratus, and these gradually growing further condensed and sink to a lower level, until rain ultimately set in." He saw the clouds and rain being formed on the spot, and could have no suspicion of their being caused by vapors rising out of the dry sand of the desert, and so he wrote faithfully according to what he saw. Although, therefore, no doubt, there are more things between heaven and earth than was dreamt of in the philosophy of Moses, when he tells us that there is a firmament between heaven and earth, dividing the waters from the waters, the time may perhaps not be far distant when we shall all agree with him on that particular point.

The nomenclature of clouds being a question which of late years has provoked considerable dispute, it seems to me, that, according to my explanation of the general atmospheric arrangements, clouds might more properly be grouped according to their cause or origin, rather than entirely according to their appearance, which is so varying and deceptive. We find, thus, two distinct groups of clouds; namely, what we may call "evaporation clouds" and "condensation clouds."

Evaporation clouds are cumulus-clouds in shape. They are formed by mixture at the summit of a current of damp air rising from the ground. They are unstable and merely indicate a stage in the upward passage of vapors. They are essentially rainless clouds, and found in the expansion or cushion of unsaturated air. They have their supply of vapor from below.

Condensation clouds are stratified clouds, cirrus, and stratus. They are formed by condensation by compression at the lower limit of the outer atmosphere of vapor. They are essentially rain-clouds, or those from which the great rain ultimately comes. They have their supply of vapor above them.

FRANK A. VELSCHOW, C.E.

A New Meteorite.

AT a meeting of the Rochester Academy of Science held Feb. 17, Mr. E. E. Howell gave an account of a new iron meteorite recently added to the Ward and Howell collection.

This meteorite was found April 30, 1888, about one and a half miles north of Welland, Ontario, Canada. It was ploughed up by Walter Caughell, and attracted attention by its specific gravity. Before throwing the mass aside as worhthless, a small piece was with much difficulty broken off. This piece, weighing five ounces, was kept by a Mr. Holland until September last, when he gave it to a friend, who, being convinced it was meteoric, forwarded it to Mr. Howell.

After careful search, the original mass was at last rediscovered in a pile of old iron. It is impossible to determine the original size of the mass, as it has been so long exposed that none of the outer crust nor characteristic pittings are preserved, but only the general form, which is a kidney-shaped mass, with the inner edge and smaller end drawn out thin. At two or three points the octahedral structure is well exposed. After being freed from all loose scales, the total weight, including the piece first broken off, is seventeen pounds and three-quarters. Mr. Howell proposed to call it the "Welland meteorite," from the locality where it was found. Mr. Howell stated that this was the second meteorite they had received from Ontario.

The first one fell about 2 P.M., Jan. 21, 1887, in the village of De Cewsville. It struck in the ditch by the side of the street, about fifteen feet from a lady who was passing along the middle of the street at the time.

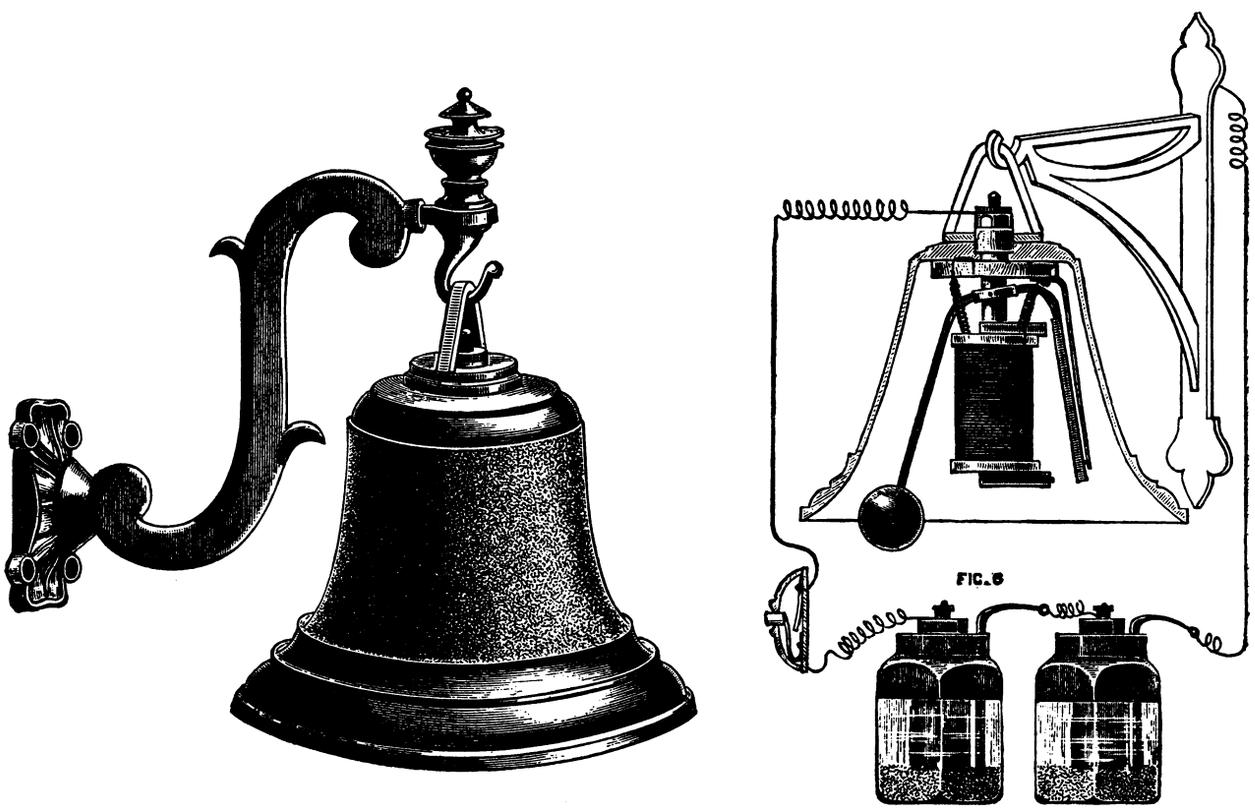
It broke through a thin sheet of ice, and was not found until the 16th of the following month, about four feet to the east of where it fell. It is an aerolite weighing twelve ounces, with specific gravity roughly calculated at 3.43. H. L. PRESTON.

Rochester, N.Y., Feb. 28.

INDUSTRIAL NOTES.

A Novel Electric Bell.

THE Jensen electric bell shown in perspective in Fig. 1, and in section in Fig. 2, possesses some novel features worthy of notice. It will be seen, by examination of Fig. 2, that the operating mechanism and the method of making the electrical connections differ materially form those in ordinary use. Only one magnet is employed instead of two, and by the use of extension pole-pieces at each end of the core the attractive force of the magnet is exerted on a line parallel to its axis. In the ordinary form, the armature acts at right angles with the axis of the magnet. This new device, owing to its compactness, is peculiarly adapted to this form of bell; and this style of magnet gives a powerful magnetic field, insuring quick and vigorou action.



FIGS. 1 AND 2.—THE JENSEN ELECTRIC BELL.

By reference to the sectional illustration, it will be noticed that the method of hanging the clapper is novel and very ingenious. Advantage is taken of gravitation, to an excellent purpose. This form of bell admits of its being used in many places where it would be impracticable to put bells of the ordinary kind. For instance, it can be hung to a clock, and with the use of proper appliances made to strike the hour, or oftener if desired. It is also adapted to church chimes, which can be rung on this principle as easily as playing on the keyboard of a pianoforte.

One great advantage of this invention in its application to locomotive bells is quite obvious. Instead of the fireman spending half his time pulling the bell-cord, the bell by this new method would be placed at the command of the engineer, the same as the whistle or brake, and would be instantly sounded and the alarm made continuous by simply turning the switch. This adaptation alone makes the invention valuable, to say nothing

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After careful search, the original mass was at last rediscovered in a pile of old iron. It is impossible to determine the original size of the mass, as it has been so long exposed that none of the outer crust nor characteristic pittings are preserved, but only the general form, which is a kidney-shaped mass, with the inner edge and smaller end drawn out thin. At two or three points the octahedral structure is well exposed. After being freed from all loose scales, the total weight, including the piece first broken off, is seventeen pounds and three-quarters. Mr. Howell proposed to call it the "Welland meteorite," from the locality where it was found. Mr. Howell stated that this was the second meteorite they had received from Ontario.

The first one fell about 2 P.M., Jan. 21, 1887, in the village of De Cewsville. It struck in the ditch by the side of the street, about fifteen feet from a lady who was passing along the middle of the street at the time.

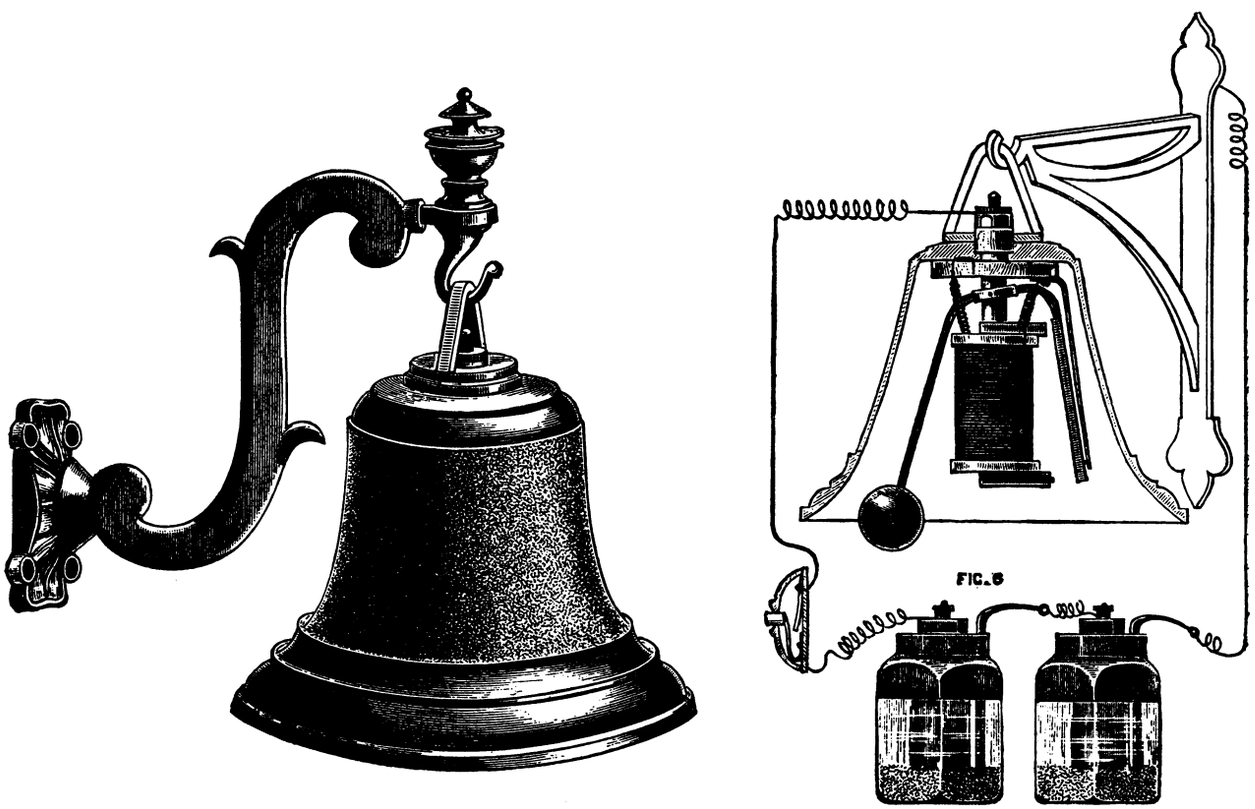
It broke through a thin sheet of ice, and was not found until the 16th of the following month, about four feet to the east of where it fell. It is an aerolite weighing twelve ounces, with specific gravity roughly calculated at 3.43. H. L. PRESTON.

Rochester, N.Y., Feb. 28.

INDUSTRIAL NOTES.

A Novel Electric Bell.

THE Jensen electric bell shown in perspective in Fig. 1, and in section in Fig. 2, possesses some novel features worthy of notice. It will be seen, by examination of Fig. 2, that the operating mechanism and the method of making the electrical connections differ materially form those in ordinary use. Only one magnet is employed instead of two, and by the use of extension pole-pieces at each end of the core the attractive force of the magnet is exerted on a line parallel to its axis. In the ordinary form, the armature acts at right angles with the axis of the magnet. This new device, owing to its compactness, is peculiarly adapted to this form of bell; and this style of magnet gives a powerful magnetic field, insuring quick and vigorou action.



FIGS. 1 AND 2.—THE JENSEN ELECTRIC BELL.

By reference to the sectional illustration, it will be noticed that the method of hanging the clapper is novel and very ingenious. Advantage is taken of gravitation, to an excellent purpose. This form of bell admits of its being used in many places where it would be impracticable to put bells of the ordinary kind. For instance, it can be hung to a clock, and with the use of proper appliances made to strike the hour, or oftener if desired. It is also adapted to church chimes, which can be rung on this principle as easily as playing on the keyboard of a pianoforte.

One great advantage of this invention in its application to locomotive bells is quite obvious. Instead of the fireman spending half his time pulling the bell-cord, the bell by this new method would be placed at the command of the engineer, the same as the whistle or brake, and would be instantly sounded and the alarm made continuous by simply turning the switch. This adaptation alone makes the invention valuable, to say nothing

Condensation clouds are stratified clouds, cirrus, and stratus. They are formed by condensation by compression at the lower limit of the outer atmosphere of vapor. They are essentially rain-clouds, or those from which the great rain ultimately comes. They have their supply of vapor above them.

FRANK A. VELSCHOW, C.E.

A New Meteorite.

AT a meeting of the Rochester Academy of Science held Feb. 17, Mr. E. E. Howell gave an account of a new iron meteorite recently added to the Ward and Howell collection.

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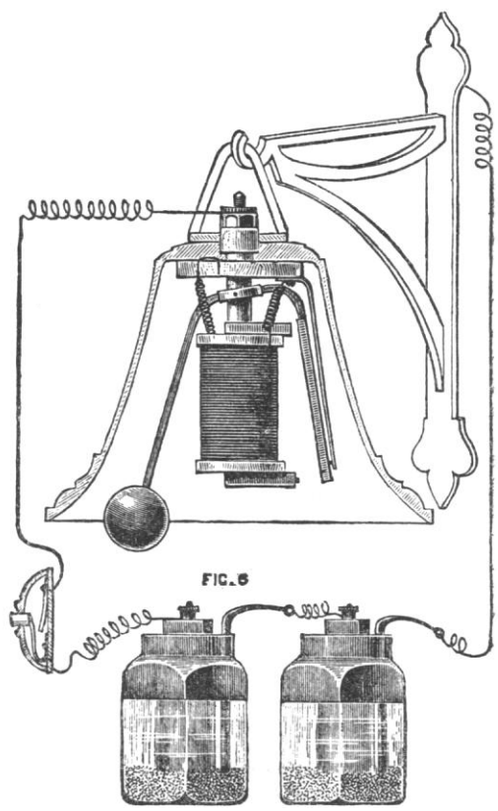

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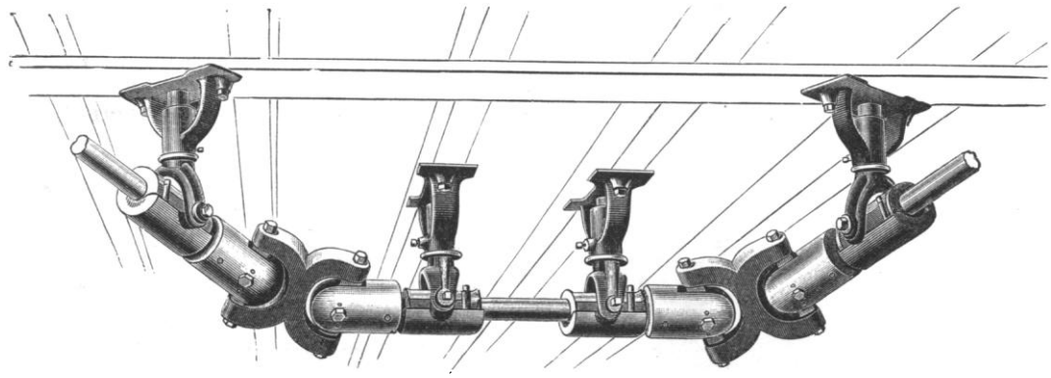
of the numerous applications, such as street-cars, mills, factories, private dwellings, and public buildings; in fact, wherever a bell is needed. These bells may be made to vibrate or make single strokes, as desired. This bell, which is extensively used in England, is being introduced into this country by Mr. C. M. Lyman of the Eureka Electric Company of this city.

The Robes Improved Shaft-Coupling.

THERE was on exhibition at the late Maritime Fair in Boston a most interesting and valuable mechanical device, of which we present an illustration. This invention has for its object to provide a universal shaft-coupling of simple construction for connecting shafts placed at a variety of angles or at different levels, or both, and which will be noiseless in its action, and will transmit motion steadily from one shaft to another with a perfectly uniform and regular speed without regard to the load, thus avoiding the sudden jerks and irregular motion common to universal shaft-couplings as heretofore constructed, and which have rendered them unsuitable for general purposes.



THE ROBES IMPROVED SHAFT-COUPLING.

The invention consists in the combination, with a pair of shafts adapted to run at different angles or levels, or both, and each having a slot at its extremity, of an intermediate connecting shaft supported in suitable bearings between the ends of the two main shafts, and having a slot at each end, and a pair of coupling-links or connecting pieces bifurcated at each end to form jaws. One of these is arranged between each of the main shafts and the adjacent end of the intermediate connecting shaft, and they are coupled with the shafts by a pair of oscillating or rocking bars, each pivoted at its centre on a pin or bolt within the slotted end of one of the shafts, in line with the axis, and having its opposite ends pivoted or journaled within the adjacent jaws of the coupling link. By this arrangement the power is transmitted from one shaft to the other in a direct axial line, and a steady and uniform motion insured under all conditions. All those who have had to labor with the appliances of the past for bringing about the same end must certainly be pleased with this forward step in mechanics.

A visitor to the exhibition who was interested in mining was impressed with the great value of this device in being so readily adjusted to all the varieties of angles required in working a mine, and intimated his intention of using one as soon as possible. Another visitor claimed that it would entirely obviate the well-known difficulty among the builders of marine engines in adjusting the propeller-shaft to the engine, the adoption of the coupling rendering the absolutely straight shaft from engine to propeller unnecessary. Another thought it exceedingly useful in enabling a canal-boat to be lifted over sand-bars and other obstructions of like character.

There are two or more in use in Boston at present, one of which has been running for three years, another two years; and both are giving perfect satisfaction. Further information may be had on application to the Wyman Machine Company, 226 Devonshire Street, Boston.

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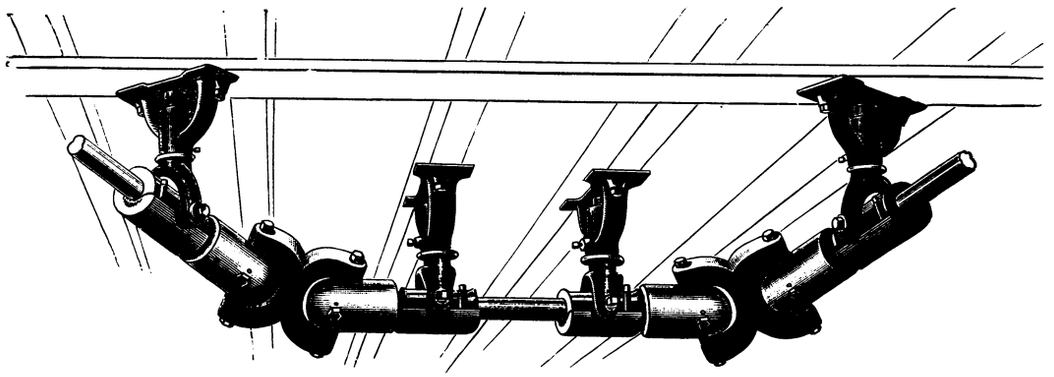

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